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14. ABSTRACT
This project involves detecting objects from various video samples by searching for local features to describe each part of the image, and feeding these detections to a grid-based Bayesian algorithm. A constrained shape manifold method for shape based recognition and retrieval has been developed through building a novel quantitative shape description scheme that constructs constrained shape spaces with the aid of physically meaningful transformations of the underlying structural invariant. The grid-based algorithm has been developed for tracking that drastically outperforms the existing algorithms in terms of computational efficiency, accuracy and robustness. Furthermore, by

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Report Title

Research Area 5: Video Dagta Mining and Target Tracking: A Model Adaptation and Feedback Control Approach

ABSTRACT

This project involves detecting objects from various video samples by searching for local features to describe each part of the image, and feeding these detections to a grid-based Bayesian algorithm. A constrained shape manifold method for shape based recognition and retrieval has been developed through building a novel quantitative shape description scheme that constructs constrained shape spaces with the aid of physically meaningful transformations of the underlying structural invariant. The grid-based algorithm has been developed for tracking that drastically outperforms the existing algorithms in terms of computational efficiency, accuracy and robustness. Furthermore, by judiciously incorporating feature representation, sample generation and sample weighting, the grid-based approach accommodates contrast change, jitter, target deformation and occlusion. Tracking performance of the proposed grid-based algorithm is compared with two recent algorithms, the gradient vector flow snake tracker and the Monte Carlo tracker, in the context of leukocyte tracking and UAV-based tracking. This comparison indicates that the proposed tracking algorithm is approximately 100 times faster, and at the same time, is significantly more accurate and more robust, thus enabling real-time robust tracking.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper	
08/29/2012	6.00	Scott Acton, Alla Aksel. An information theoretic trackability measure, Proc. SPIE Electronic Imaging, San Francisco, California. 23-JAN-12, . : ,
08/29/2012	7.00	Scott Acton. Trackability, IEEE International Conference on Image Processing, Orlando, Florida. 30-SEP-12, . : ,
09/30/2013	10.00	Scott T. Acton. Speckle reducing diffusion for ultrasound image enhancement using the structural similarity image measure, IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing. , . : ,
09/30/2013	11.00	Rituparna Sarkar , Suvadip Mukherjee, Scott T. Acton. Shape descriptors based on compressed sensing with application to neuron matching, Asilomar Conference on Signals, Systems and Computers. 04-NOV-13, . : ,

TOTAL: **4**

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received		Paper
08/29/2012	8.00	Qian Sang, Zongli Lin, Scott T. Acton. An enhancement to the grid-based Bayesian tracker for erratic targets, SPIE (08 2012)
09/30/2013	9.00	Qian Sang , Zongli Lin, Scott Acton. A grid-based tracker for erratic targets, IEEE Transactions on Human-Machine Systems (09 2013)
10/02/2011	4.00	Saurav Basu, Vyacheslav Krushkal, John A. Hossack, Scott. T. Acton. Constrained Shape Manifold for Shape Based Recognition and Retrieval, IEEE Transactions on Image Processing (09 2011)
10/03/2011	5.00	Xinmin Liu, Zongli Lin, Scott T. Acton. A Grid-based Bayesian Approach to Robust Visual Tracking, Digital Signal Processing (10 2011)
TOTAL:	**4**	

Number of Manuscripts:

Books

Received	Paper
TOTAL:	

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
Qian Sang	0.31
FTE Equivalent:	**0.31**
Total Number:	**1**

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Scott T. Acton	0.10	
Zongli Lin	0.22	
FTE Equivalent:	**0.32**	
Total Number:	**2**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME
Total Number:

Names of personnel receiving PHDs

NAME
Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

This project involves detecting objects from various video samples by searching for local features to describe each part of the image, and feeding these detections to a grid-based Bayesian algorithm. The results obtained include

1. A constrained shape manifold method for shape based recognition and retrieval has been developed through building a novel quantitative shape description scheme that constructs constrained shape spaces with the aid of physically meaningful transformations of the underlying structural invariant. A paper [1] reporting on this result is currently under revision for IEEE Transactions on Image Processing.

2. A grid-based algorithm has been developed for tracking that drastically outperforms the existing algorithms in terms of computational efficiency, accuracy and robustness. Furthermore, by judiciously incorporating feature representation, sample generation and sample weighting, the grid-based approach accommodates contrast change, jitter, target deformation and occlusion. Tracking performance of the proposed grid-based algorithm is compared with two recent algorithms, the gradient vector flow snake tracker and the Monte Carlo tracker, in the context of leukocyte tracking and UAV-based tracking. This comparison indicates that the proposed tracking algorithm is approximately 100 times faster, and at the same time, is significantly more accurate and more robust, thus enabling real-time robust tracking. A paper [2] reporting on this result has been published in Digital Signal Processing.

3. A method was developed to enhance its capability in accommodating the tracking of targets in video with erratic motion, by introducing adaptation in the motion model and iterative position estimation. Tracking performance of the resulting algorithm is compared with the original grid-based Bayesian tracker in the context of leukocyte tracking and UAV based vehicle tracking to demonstrate its effectiveness in dealing with erratic target movement. Relevant results have been presented at the 2013 IS&T/SPIE Electronic Imaging [3] and are under review for publication in the journal Pattern Recognition [4].

4. Trackability, defined as a numerical measure associated with a video for a given target that increases with decreasing difficulty of tracking the target, is examined. The method applied to quantify trackability is grounded in information theory. First, a measure of similarity between the target signal and the template is established by way of mutual information. This mutual information becomes a three variable analysis as the influence of clutter is considered. The effects of video quality are included in a traditional Shannon- Hartley computation and the motion of the target and registration of the video are used to modify this quality motion term. The sum of both terms, computed in bits per second, yields trackability. Fifteen tracking experiments show a promising Spearman rank correlation between the trackability and the actual tracking performance. A paper [5] reporting on this work has been presented at the 2012 19th IEEE International Conference on Image Processing.

5. A trackability measure was developed in an information theoretic framework. The tools of information theory allow a measure of trackability that seamlessly combines the video dependent aspects with the target-dependent aspects of tracking difficulty using measure of rate and information content. Specifically, video quality is encapsulated into a term that measures spatial resolution, temporal resolution and signal-to-noise ratio by way of a Shannon-Hartley analysis. Then, the ability to correctly match a template to a target is evaluated through an analysis of the mutual information between the template, the detected signal and the interfering clutter. The developed trackability measure is compared to the performance of a recent tracker based on scale space features computed via connected filters. The results show high Spearman correlation magnitude between the trackability measure and actual performance. A paper [6] reporting on this work has been presented at the 2012 IS&T/SPIE Electronic Imaging.

6. An adaptive approach to enhancing images obtained from an array of ultrasonic transducer elements has been proposed and evaluated. The basic algorithm is driven by a system of partial differential equations that 1) reduce speckle by way of the instantaneous (local) coefficient of variation and 2) force congruence with an anatomical model using a well-known perceptual quality metric. A differential form of the quality metric, the structural similarity image measure (SSIM), is derived and applied. This update mechanism registers the image data to the model, thus solving segmentation simultaneously with enhancement. The algorithm, called SSIM diffusion, is tested on a needle placement application in phlebotomy in which delineation of a vessel boundary is required. A group of images obtained from a portable C-scan ultrasonic sensor is used to evaluate the enhancement and segmentation algorithm. Comparisons to a standard speckle reducing diffusion algorithm show that the model-based SSIM diffusion superior enhancement with a 67% increase in measurable image quality over the original. A paper [7] reporting on this work has been presented at the 2013 5th IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing.

7. A novel compressed sensing based Fourier shape descriptor method to compute the shape feature vector of an arbitrary object has been proposed. First, the object contour obtained via segmentation is represented as a complex signal. We then formulate an optimization problem that exploits the sparsity of the shape feature of the contour. This results in a reduced size feature vector, which can efficiently represent the shape of an object as illustrated by the reconstruction results. Appropriate for general shape retrieval problems, we demonstrate the efficacy of our algorithm by retrieving structurally similar neurons from a database. Currently, the representation and matching of neurons, given the heterogeneous nature of the neuronal morphology and the characteristically complex branching patterns, is an open problem. Retrieval of structurally similar neurons will potentially enable classification of neurons imaged. The retrieval results obtained using our method provide evidence of efficacy with a 27% improvement over Sholl analysis, which is a standard shape descriptor used in neuroscience. A paper [8] reporting

on this work has been presented at the 2013 Asilomar Conference on Signals, Systems and Computers.

References:

[1] S. Basu, V. Krushkal, J.A. Hossack and S.T. Acton, “Constrained shape manifold for shape based recognition and retrieval,” IEEE Transactions on Image Processing, under revision.

[2] X. Liu, Z. Lin and S.T. Acton, “A grid-based Bayesian approach to robust visual tracking, Digital Signal Processing, Vol. 22, No. 1, pp. 54-65, 2012.

[3] Q. Sang, Z. Lin and S.T. Acton, “An enhanced grid-based Bayesian array for target tracking,” Proceedings of IS&T/SPIE Electronic Imaging Science and Technology: Computational Imaging XI, Vol. 8657, 0J 1-11, Burlingame, CA, February 5-7, 2013.

[4] Q. Sang, Z. Lin and S.T. Acton, “A grid-based tracker for erratic targets,” Pattern Recognition, under review.

[5] S.T. Acton, “Trackability,” Proceedings of the 2012 19th IEEE International Conference on Image Processing, pp. 425-428, Orlando, FL, September 30-October 3, 2012.

[6] S.T. Acton and A. Aksel, “An information theoretic trackability measure,” Proceedings of IS&T/SPIE Electronic Imaging Science and Technology: Computational Imaging X, Vol. 8296, 0W 1-12, Burlingame, CA, January 23-24, 2012.

[7] S.T. Acton, “Speckle reducing diffusion for ultrasound image enhancement using the structural similarity image measure,” Proceedings of the 2013 5th IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP), pp. 153-156, St. Martin, French West Indies, France, December 15-18, 2013.

[8] R. Sarkar, S. Mukherjee and S.T. Acton, “Shape descriptors based on compressed sensing with application to neuron matching,” Proceedings of Asilomar Conference on Signals, Systems and Computers, pp. 970-974, Pacific Grove, CA, November 4-7, 2013.

Technology Transfer